ANIMAL BEHAVIOR AND THE DESIGN OF LIVESTOCK AND POULTRY SYSTEMS

Restraint Of Livestock

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During twenty years of work on livestock handling and design of restraining devices for animals I have observed that many people attempt to restrain animals with sheer force instead of using behavioral principles. Improvements in the design of restraining devices enhances animal welfare and will reduce stress and injuries. A series of surveys conducted by the author showed that changing the design of a squeeze chute would reduce injuries to cattle (Grandin 1975), but there is still a great need to improve squeeze chutes that are used on larger feedlots and ranches. Under the best conditions, cattle can become bruised or injured in a conventional squeeze chute. A survey of seven major feedlots by Brown et al.,(1981) indicated that in five of the feedlots 1.6% to 7.8% of the animals were bruised. Even though bruises would heal by marketing time, pain and trauma may reduce weight gain. Cattle can become asphyxiated by excessive pressure on the carotid arteries. In a standard hydraulic stanchion squeeze chute used in most commercial feedyards an inexperienced operator can cause 2% of the cattle to collapse from pressure on the carotid arteries (Grandin 1980). A collapsed animal will die if the operator fails to release it immediately. Excessive hydraulic pressure can cause severe injuries. The animal's diaphragm can be ruptured (Fulton, R. 1973 personal communication). Excessive pressure can break the pelvis (Miles, D. 1992 personal communication). The author has also observed that excessive squeeze pressure can cause a significant reduction in weight gain. Good management can prevent many of these problems but there is still a great need for improved restraint devices for use on ranches and feedlots. I did not realize how poor existing chutes in feedlots were until I developed restraint devices for calf and beef slaughter plants.

Over the years I have designed several different types of cattle restraint devices for use in meat packing plants. During the course of developing these devices I have learned that the use of behavioral principles will keep both cattle and pigs calm. Many of these ideas could be incorporated into new designs for cattle restraining devices for the ranch farm or feedlot.

The principles of low stress restraint are:

1. Solid sides or barriers around the cattle to prevent them from seeing people deep inside their flight zone. This is especially important for wild or excitable cattle.

2. To prevent lunging at the headgate, the bovine's view of an escape pathway must be blocked until it is fully restrained. This principle does not apply to pigs.

3. Provide non-slip flooring for all species of animals.

4. Slow steady motion of a restraint device is calming, while sudden jerky motion excites. Applies to all species.

5. Use the concept of optimal pressure. Sufficient pressure must be applied to provide the feeling of restraint, but excessive pressure that causes pain or discomfort must be avoided. This principle applies to all species.
6. The entrance of the restraint device must be well lighted. All species must be able to see a place to go.

7. Livestock will remain calmer if they can see other animals close to them.

8. Engineer equipment to minimize noise. High pitched noise is more disturbing to livestock than a low pitched rumble from a conveyor.

9. Restraint devices must be designed to avoid uncomfortable pressure points on the animal's body.

10. Restrain livestock in an upright position.

The author learned the importance of these principles while designing an improved humane restraint device for kosher slaughter of cattle and during the development of the double rail conveyor restrainer for both calves and cattle.

For the last eighteen years, large beef slaughter plants have been using the V restrainer system for restraining cattle during stunning and shackling. It was invented by Edwards (1972), Schmidt (1972) and Willems and Markey (1972). The V restrainer was a major humane and safety improvement over old style knocking boxes, but there were still problems with it. Cattle balked at the entrance and the stunner operator had to reach excessively to place the cattle bolt stunner in the animal's forehead. Researchers at the University of Connecticut developed a laboratory prototype double rail restrainer for calves and sheep (Giger et al.,1977, and Westervelt et al.,1976). They determined that it was a good low stress method for holding an animal. Grandin (1988) developed an improved entrance and animal size adjustment mechanism for this system and installed it in a commercial calf and sheep slaughter plant.

Further modifications were made by the author and the system was installed in a cattle slaughter plant (Grandin 1991). Cattle walk up a ramp to the restrainer entrance and straddle a stationary leg spreader bar which positions their legs on each side of the moving double rail:

they are stunned with a captive bolt and the shackle is attached to one rear leg. The stunned animals are discharged off the double rail onto a moving table conveyor. The shackle trolley is then picked up by a moving inclined conveyor which moves the stunned shackled animal to the bleed area. The double rail is now being used in fourteen large beef slaughter plants which constitutes approximately one-third of North American fed cattle.

To induce the cattle to stay still and ride quietly, the solid hold down rack MUST be long enough so that the animal entering the restrainer can NOT see out until it's feet are completely off the enterance ramp.
Another project on kosher restraint device designs involved modifying an existing humane upright restraint device which had been originally patented in 1963 by M. Marshall and his colleagues. The major modifications were to reduce the amount of pressure the device applied to the animals and installation of a solid barrier around the animal's head to prevent it from seeing people.

This drawing illustrates (on the left side, in front of the animal) the solid barrier that is necessary to block the animal's vision.
The sides of the ASPCA box must also be completely solid.
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The device restrains the animal by pushing it forward with a rear pusher gate and a lift is raised under it's belly. The head is restrained by a yoke that raises up and a bracket presses against the animal's forehead. Restricting vertical travel of the belly lift to 71 cm (28in) prevented excessive pressure from being applied to the thoracic area. Pressure regulators were installed to reduce pressure applied by the pusher gate and head holder.

I will now return to the ten restraint principles and explain both practical observations and research data that support these principles. One overall finding was that very small changes in the dimensions or design of the device had a tremendous effect on the behavior of the animal. Small differences in dimensions sometimes made the difference between the animal remaining calm or the animal struggling and fighting restraint.

**Principle 1.**

Solid sides to restrict a bovine's vision have been used for years on chutes leading up to cattle restraint devices. They help keep cattle calmer (Rider et al., 1974, Grandin 1987). They are especially beneficial for wild cattle and animals such as elk, deer or bison. Chutes with solid sides, front and top have a calming effect when they are used for holding cattle during pregnancy testing and artificial insemination (Grandin 1993, Parsons and Helphinstine 1969). Don Kinsman at the University of Connecticut found that blocking an animal's vision reduced physiological responses. Buffalo and elk breeders have learned from practical experience that solid sides and a solid gate in front of the headgate of a squeeze chute help keep the animals calmer. However cattle squeeze chutes have always had open barred sides and the person operating the chute is deep inside the bovine's flight zone. Observations at a meat packing plant of the kosher restraining chute have indicated that completely solid sides and a solid barrier around the animal's head which prevents it from seeing people and moving machinery had a calming effect. Wild or agitated cattle are more likely to struggle in a restraint device when they see people deep inside their flight zone (Grandin 1994a,b). Covering the open barred sides on a squeeze chute will keep cattle calmer. On new squeeze chute designs cabinet doors could be built.

**Principle 2.**

To prevent wild or excitable cattle from lunging at the headgate or attempting to run through a restraint device before they are caught, the view of an escape pathway must be blocked until the animal is completely restrained. On squeeze chutes, a solid gate located approximately 1.2m (4ft) in front of the headgate will stop lunging. This will help prevent shoulder and neck injuries. This principle also applies to the conveyorized system shown. Observation at the first two cattle slaughter plants where the system was installed indicated that the length of the solid hold down rack was critical. If it was too short the cattle struggled. When it was lengthened the cattle remained calm. The secret was to make the solid hold down long enough so the animal's hind feet were off the entrance ramp, and it settled down on the conveyor before it's head emerges from under the hold down (Grandin 1991). In other words, the animal's vision of an avenue of escape was blocked until it was fully restrained. It is important that it had the "feeling" of being restrained before it could see out. This principle applies to cattle and wild ruminants that are not completely tame. It does not apply to pigs, special fed veal calves or completely tame cattle. The length of the hold down rack had no effect on tame special fed veal calves.

**Principle 3.**
Restraint devices where an animal stands on a floor must be equipped with non-slip flooring.

![Restraint devices](image)

Slick floors will cause animals to panic and become injured. The entrance ramp on the double rail restrainer is also non-slip and equipped with cleats.

![Slick ramp](image)

Cattle will willingly walk down the ramp and straddle the conveyor. Many people mistakenly believe that animals will enter more easily if they are forced to slide down the ramp. Slick ramps are more likely to make the animals balk and attempt to back up when they feel their feet slip. I have to constantly argue with meat plant managers to prevent them from moving cleats.

**Principle 4.**

Observations of cattle in the kosher restraint box indicated that slow steady movements of the apparatus had a calming effect and sudden jerky motion excited the animals (Grandin 1994a, 1993a,c).
In a conventional squeeze chute the headgate often has to be slammed quickly on the cattle to prevent them from lunging through it. Since the solid sides on the kosher chute greatly reduced lunging it was now possible to experiment with slow steady application of pressure. The elimination of sudden bumping of the cattle resulted in calmer animals compared to a squeeze chute in a feedlot. Engineers should choose pneumatic or hydraulic control valves that have good throttling capability. The speed that various parts of the restraint device move should be proportional to movement of the control lever. Valves which are stiff and require high effort to operate should be avoided. All moving parts of either a hydraulically or pneumatically controlled restraint device should also be equipped with flow control valves. These valves will prevent sudden slamming of gates and other parts of the device when the operator pushes the control lever all the way down. When the flow control is set it acts as a governor. The operator can only control the speed below the flow control setting.

**Principle 5.**
Many people make the mistake of applying more and more pressure when a restrained animal struggles. I've spent many hours operating a kosher restraint chute to determine the best method to operate it. I discovered that there was an optimal pressure which had to be tight enough to provide the feeling of being held but excessive pressure would cause struggling. Hydraulic or pneumatically powered restraint devices must be equipped with pressure regulating devices to prevent a careless operator from applying excessive pressure which could injure the animals. Moderate pressure can have a calming effect on the nervous system. Pressure applied to the sides of a pig will cause it to relax. Piglets placed in a padded V restrainer fall asleep (Grandin et al., 1989). Pigs held in a carrier sling with their legs protruding through four holes will also fall asleep (Panepinto 1983).

**Principle 6.**

To reduce stress animals must willingly enter a restraint device. Stress levels are greatly increased if an animal balks and refuses to enter or several attempts are required to restrain it. Use of a poorly designed restraint device where over 30 seconds were required to catch a bovines head resulted in greatly elevated cortisol levels (Ewbank et al., 1992). Adequate lighting is required so that the animal can see where it is going. Animals will not enter a dark restraint device. In indoor facilities lamps must be used to illuminate the restrainer entrance. In the kosher restraint box a light mounted in front of the headgate encouraged cattle to place their heads through the lighted opening. The lamps must never shine directly into the eyes of approaching animals. Animals have a basic behavioral tendency to move from a darker area towards a more brightly illuminated area (Lambooij and Von Putten 1993, Grandin 1987). When a dark box is used a small window in the front gate will encourage cattle to enter.

**Principle 7.**

Cattle and other ruminants are herd animals and isolating an animal from it's herdmates will cause stress and an isolated animal is more likely to become agitated. Joseph Stookey at the University of Saskatchewan found that cattle would stand more quietly on a scale when they could view an animal in front of them, which was less than 1 meter away. One of the advantages of all types of conveyorized restraint systems is that the cattle, pigs or sheep can see and touch each other. This results in visibly calmer animals compared to individual restraint.

**Principle 8.**

High pitched noise is stressful to cattle and sheep. Both sheep and cattle have ears that are more sensitive to higher frequencies than human ears (Ames 1974, Algors 1984). Observations indicated that a high pitched whine from a hydraulic line was more likely to cause cattle to become agitated than a low pitched rumble from conveyor gears. Sudden noises such as metal clanging and banging and air exhausts cause animals to startle, flinch and refuse to move through a chute. Air exhausts should be equipped with silencers or piped outside. Clanging and banging of metal can be reduced by rubber pads and the use of plastic guides on moving restrainer parts. High pitched hydraulic noise can be reduced by using pumps engineered to reduce noise and reducing fluid velocity via the use of larger diameter plumbing.

**Principle 9.**

Many existing restraint devices are poorly designed and have uncomfortable pressure points that gouge into the animal. During development of the double rail restrainer I learned that a small mistake in the design resulted in pressure points which caused the animals to struggle. On the calf restrainer, the adjustable sides are designed to avoid pressure on the calf's shoulder joints (Grandin 1988). Many restraint devices press against an animal with bars or other parts that have a diameter that is too small. Uncomfortable pressure can be reduced by pressing against the animal with a wider surface. Pigs stopped squealing and were quieter in a restraint device after a 4cm (1.5in) diameter pipe which dug into their backs was replaced with a 15cm wide metal plate that distributed the pressure from the device over a wider area of the back. On the kosher restraining box replacement of a 7.6cm (3in) flat metal bar that pressed on the animal's forehead with a 20cm (8in) wide metal plate covered with two layers of conveyor belting, greatly reduced struggling. Distributing the pressure across a larger area of the forehead reduced discomfort (Grandin 1994a,b). If a restraint device is designed to fit the animal, padding is often not required on devices for holding cattle, pigs and sheep. A thin easily sanitized pad such as conveyor belting is often all that is needed on parts that press against body surfaces. A device that is properly designed should fit the animal the way a
molded fiberglass chair fits a person. On the cattle double rail, the U-shaped curve of the rails was designed to fit the curve of the animal's brisket (Grandin 1991).

This prevents a pressure point on the brisket. Heavy soft padding is often required on restraint devices for extremely flighty animals such as horses and deer which have long fragile legs. Sometimes a retractor system that works for one type of animal may work poorly for another. I have observed that old fashioned fat pigs fit comfortably into a V conveyor restrainer that is used in meat packing plants. Extremely heavily muscled market pigs with large hams are not adequately supported by the V (Grandin 1993b). These pigs will squeal and struggle and round fat pigs become quiet in the V. The double rail restrainer is more suitable for very lean or very muscular pigs.

Restraint devices must be designed to prevent choking of animals by pressure on the carotid arteries. Conventional squeeze chutes with a curved bar stanchion headgate must be properly adjusted so that the V shape of the squeeze sides will prevent the cattle from laying down and pressing the bottom part of the neck against the stanchion (Grandin 1980). In research laboratories and veterinary clinics where no squeeze sides are used a straight bar stanchion should be used. An animal can lay down in a straight bar stanchion with little danger of choking.

Principle 10.

Animals will remain quieter and show fewer visible signs of agitation if they are held in a comfortable upright position. Dunn (1990) found that inverting cattle to an upside down position caused a greater increase in cortisol levels compared to upright restraint. When sheep were given a choice they preferred being restrained in an upright position (Rusher 1986). Observations of cattle inverted onto their backs indicated that the animals resist inversion. They will twist their heads and attempt to keep their head upright during inversion. Designers of restraint equipment need to think about how a device would feel to the animal. Some devices are very poorly designed. Many squeeze chutes on the market are equipped with extension bars on the head gate to prevent cattle from tossing their heads. Unfortunately these bars often hit the animal on the jaw when the herd is caught. These bars make working on the head more convenient but at the expense of injuring the animal's jaw. Even when an expert operator ran a hydraulic chute equipped with these extension bars, one in twenty cattle was bashed hard in the jaw by the bars. Some people have attempted to replace mechanical restraint devices with an electronic immobilizer that paralyzes the animal with a small electric current. Several different scientific studies have shown that contrary to the manufacturer's claims, these devices are highly aversive and have absolutely no anesthetic or analgesic effect (Grandin et al., 1986, Passkey 1986, Lambooy 1985). These devices have been banned in parts of Australia and England and they should not be used.

Need For Better Restraint

There is a need to develop better restraining devices for both cattle and pigs. The double rail conveyor restrainer system could be easily adapted for use in large feedlots. Trials done by Gearn Industries in Texas showed that trauma to the bovine's shoulders and neck could be almost eliminated. A headgate mounted on the end of the double rail restrainer is already being successfully used for kosher slaughter of cattle (Grandin 1993b, 1994).
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This same equipment would also work for handling large numbers of feedlot cattle. The reduction in subclinical injuries are likely to quickly pay for the system. Packing plants have reported finding large haematomas in cattle shoulders. These would be caused by hitting the headgate of a conventional squeeze chute too hard.

There is also a need to develop a good portable pig restrainer to replace snout snaring. Replacement of snout snaring with a more comfortable restraint method may help reduce stress in pigs and improve productivity by reducing fear of handlers. Hemsworth (1993) stated that pigs which are fearful have lowered productivity.

There is much controversy in Europe concerning the stressfulness of restraint devices used for kosher slaughter. Most problems with cattle stress can be minimized by designing restraint equipment according to the ten principles and operating it properly. Very low cortisol readings of 15 ng/ml can be obtained when cattle are slaughtered while held in a head restraint device (Tume and Shaw 1992, Shaw, F. personal communication). Restraint of beef cattle in conventional squeeze chutes results in cortisol readings of 25 to 33 and 63 ng/ml (Mitchell et al.,1988, Zavy et al.,1992). It is essential that the cattle walk in willingly without prodding and they must be caught on the first attempt. Cortisol levels in cattle inverted onto their backs was a high 93 ng/ml (Dunn 1990). It is likely that pigs have much higher stress levels during restraint and handling than cattle. Recent studies in England and Australia indicated that average cortisol levels during slaughter was way over 150 ng/ml (Warriss et al.,1994; Shaw et al.,1995).

Problems With Excitable Animals

I have observed during travel to many operations increasing problems with very excitable cattle that are more likely to go into a frenzy when they are restrained. These animals are sustaining more shoulder and neck injuries when they are caught in the headgate of a squeeze chute compared to calmer cattle. Certain genetic lines of European Continental cross cattle have the most severe problems. Indiscriminant selection for lean cattle with rapid weight gain has contributed to the problem. Designing humane safe restraint equipment for these animals is extremely difficult because they panic and become self destructive. Their temperament more closely resembles the temperament of a horse. The author has observed cattle that have torn off their hooves when their legs were caught. These animals may be calm and quiet when they are in familiar surroundings such as their home ranch but they are more likely to panic when they are brought into the strange noisy environment of a meat packing plant or auction market. The author observed fed feedlot cattle at a meat packing plant which were so excitable that it was impossible to handle them quietly in a state of the art facility. The cattle kicked, fell down, injured their legs and many individuals went into a total panic in the double rail (center track) restrainer. Breeders must select cattle for a calm temperament. Attempting to solve the excitable cattle problems by changing the design of equipment is treating the symptoms of the problem instead of the cause of the problem. Problems with excitable cattle are not confined to handling and restraint. These animals have difficulty adapting to any novel environment such as a feedlot or bull test station.

Similar excitability problems have also been observed in pigs. Pigs with an excitable temperament are impossible to handle quietly in a high speed 1000 head per hour slaughter plant. Breeders need to select animals with a calm temperament.
Importance of Management

The best restraint equipment in the world is useless if it is operated in a careless or rough manner. Equipment can be engineered to enable an inexperienced person to operate it but there is no way engineering can prevent a rough or careless person from stressing or injuring the animals. It is the responsibility of management to control the behavior of their employees. During the last twenty years I have observed that operations with good handling have management that trains their employees and rough handling is not tolerated. Places with rough handling almost always have lax management or management that does not care.

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